



Compositional Impact of Io Volcanic Emissions on Jupiter's Magnetosphere and the Icy Galilean Moons

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The magnetospheric ion population of Jupiter is dominated by the 1000 kg/s of iogenic material constantly ejected by Io volcanism as neutral gas (~ 1 kg/s goes out as high speed dust grains), subsequent atmospheric losses to the Io torus, and radial transport of torus ions throughout the magnetosphere. As that magnetosphere is greatly distended in radial size by the iogenic plasma loading, so are surfaces of the other Galilean moons also significantly, and perhaps even dominantly, affected by iogenic plasma bombardment, e.g. at the level up to 0.2 kg/s heavy ions (mostly O and S) onto Europa as per local plasma ion measurements. In comparison, cometary impacts onto Io deliver about 0.02 kg/s of impact ejecta to Europa via ballistic transfer through the Jupiter system. The magnetosphere of this system operates as a powerful engine to produce and transport ions from the Io source to the surfaces of these other moons, and any future orbiter missions to these moons must account for surface distributions of the iogenic material and its chemical effects before real assessments can be made of sensible chemical materials otherwise arising from primordial formation and subsequent evolution of these moons. This is a fundamental problem of space weathering that must be addressed for all planetary bodies with thin atmospheres and direct surface exposure to their space plasma environments. Long-standing debates from Galileo Orbiter measurements about the origins of hydrate sulfates at Europa present examples of this problem, as to whether the sulfates arise from oceanic minerals or from iogenic sulfur chemistry. Any orbiter or landed mission to Europa for astrobiological investigations would further need to separate the potential chemical biosignatures of life or its precursors from the highly abundant background of iogenic material.

Although no single ion carries a tag identifying it as of iogenic or other origin, the elemental abundance distributions of ions to be measured throughout the jovian magnetosphere and in the local moon environments can act as tracers if we know from direct measurements and models the distributions at the mostly likely sources, i.e. at Io. However, our knowledge of these abundances are very limited from earlier in-situ and remote measurements, mainly confined to major (S, O) and some minor (Na, K, Cl) species with abundances at or above a few percent relative to O. Future in-situ plasma measurements by the planned Jupiter Europa Orbiter and Jupiter Ganymede Orbiter missions should extend the abundance coverage to minor and even trace elemental species. For Europa astrobiological investigations it is also important to specify iogenic inputs and surface processing of isotopic species. We discuss the range of abundance distributions arising from models for Io hot volcanic emissions, and from the subsequent dynamics of ion injection, magnetospheric transport, and icy moon surface bombardment.